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A Comparative Study of Hydrogen Peroxide in Treating Milk for Cheddar Cheese Making

Mounir Ramzi Nagmoush
Utah State University

A COMPARATIVE STUDY OF HYDROGEN PEROXIDE IN TREATING MILK FOR CHEDDAR CHEESE MAKING

by

Mounir Ramzi Nagmoush

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INTRODUCTION

In many countries of the world and in some parts of the United States milk is produced which has a high bacterial contamination. Such milk of undesirable quality is frequently delivered to factories engaged in the manufacture of cheddar cheese. This milk commonly contains large numbers of lactic acid-producing bacteria or other types of microorganisms which cause objectionable flavors and textural defects in the cheese. The improvement of the quality of milk supply under some conditions is a matter of great difficulty so that the manufacture of inferior quality milk into cheese is a problem often encountered.

In the United States pasteurization of milk is used to reduce the bacterial content and give the cheese maker control over the manufacturing process. Public health officials favor pasteurization as a protection against pathogens; however, in many areas of the world pasteurization is not available. Although pasteurization of milk for cheddar cheese offers certain advantages such as destruction of pathogenic bacteria which may be present, and control of certain undesirable fermentations, experience has shown that pasteurized milk cheese develops flavor slowly and, even with extended ripening, does not have as satisfactory a flavor as good raw milk cheese. The slow ripening usually is attributed to the destruction by heat of certain essential bacteria and enzymes normally present in milk.

Pasteurization, however, destroys many enzymes indigenous to milk as well as some beneficial organisms; consequently, cheese made from pasteurized milk ripens more slowly than cheese made from raw milk. For years, leading dairy technologists have been laboring assiduously but quite unsucessfully

to produce cheese free from undesirable organisms yet comparable in flavor and in the rapidity of ripening to the best quality of raw milk cheese. Pursuant to these objectives a number of methods such as replenishing the enzymes in milk destroyed by pasteurization, the use of select ripening cultures, and the use of mixtures of various percentages of raw and pasteurized milk have been tried but without complete success.

These objectionable features of pasteurization led to interest in another method such as the treatment of milk with edible hydrogen peroxide to control fermentation by means of its germicidal and inhibitory action.

This comparative study was conducted to determine the effect of the germicidal properties of hydrogen peroxide in treating raw milk for cheddar cheese making in relation to the flora, quality, and ripening of the cheese.

This study was concerned with the remedial measures which can be applied to milk to overcome some defects in the cheese.

The antiseptic and germicidal properties of hydrogen peroxide are well known. A study involving the use of hydrogen peroxide and catalase has many possibilities in the dairy industry, and the practical aspects of this problem are numerous. Some phases are herewith indicated:

1. If hydrogen peroxide could be used to improve the general quality of cheddar cheese, it would be a boon to the industry and should have a value in the manufacture of cheddar cheese for shelf curing purposes, canning, processing, and for natural ripening in transparent packages.
2. It was believed that the use of hydrogen peroxide and catalase would increase the safety of raw milk cheese. (Kernsman, 1934, found that 0.1 percent of hydrogen peroxide killed E. coli, E. typhi and staphilococcus.)
3. If hydrogen peroxide could be used for destroying organisms harmful in milk and thus for preventing undesirable fermentation, yet leave intact more of the natural enzymes than is possible in accepted pasteurization

procedures, the cheese treated with hydrogen peroxide and catalase might ripen faster than pasteurized-milk cheese and have a finer and more pronounced flavor.

4. If approved by public health authorities in the United States, treating milk with hydrogen peroxide would be a simple method of reducing bacterial content in small communities and rural areas. Such procedure would be very practical in preventing growth of bacteria in milk produced under unsanitary conditions.
5. If the use of hydrogen peroxide could be proved practicable, a beneficial program in most countries and especially in the Middle East where dairy equipment and pasteurizers are not readily available and where the production of unsanitary milk predominates might be established.
6. Since this process does not require special equipment it might prove economical and might become, in the future, a useful method of reducing the bacterial content of milk and preserving some of the natural characteristics of the raw milk for cheese making.

REVIEW OF LITERATURE

Thenard (1), a French chemist, discovered hydrogen peroxide in 1818 when he caused hydrochloric acid and sulfuric acid to react upon barium peroxide (H_2SO_4 plus BaO_2 ----------> H_2O_2 plus $BaSO_4$). He recognized the great interest which laboratory research and industrial application could take in this new product. In 1818 the Academy of Science of France was convoked to hear the great master's report on his important discovery. Thenard succeeded in preparing a highly concentrated solution capable of yielding 125 volumes of oxygen per liter by successive treatment at 0°C. with hydrogen peroxide but found that it was not practical to prepare solutions which yielded more than 50 volumes of oxygen. As to the method of

preserving hydrogen peroxide, Thenard wrote, "It is necessary to pour it into a long glass tube closed at one end, cork the other end and put the tube into ice" (1).

Since 1900 numerous investigations have been carried out regarding the use of hydrogen peroxide in the sterilization of milk. In 1901 Jablin and Gennet (2) stated that the addition of 8% hydrogen peroxide of a 12% strength, acidified with calcium carbonate, had been used as a preserving agent for milk and that the consumption of one half of a liter daily of the treated milk for two consecutive months resulted in no pertubation or damage.

During the same year H. Chick (3) reported in the Zentral-Blatt F. Bakter u. Parasitenk review that he had performed interesting tests on a method for the complete sterilization of milk by the addition of hydrogen peroxide, and found that he obtained positive results on both milk obtained fresh from the cow and on milk in which lactic acid bacteria had multiplied.

In the same review, A. Risam (4) reported that he observed favorable results in the use of hydrogen peroxide; but he asserted that the so-called medical product was not suitable for the preservation of milk because it contained barium and arsenic compounds. Three years later L. Gordon (5) dealt with the lethal action of hydrogen peroxide on bacteria and showed a complete efficiency on the coliform type. Bonjean (6) in 1910 also considered the problem of the purity of the hydrogen peroxide and concluded that this compound might be successfully used for the sterilization of milk if only it could be made available in a pure form.

In 1903 Budde (7) recommended the use of hydrogen peroxide in combination with heat as a means of sterilizing milk. This process, known in Europe as "Buddizing," consisted of heating the milk to 50°C. and adding enough hydrogen peroxide to give a final concentration of 0.03% to 0.035%. After being stirred for 15 to 30 minutes, the milk was drawn into bottles

which were tightly stopped and then held in a water bath at 50°C. for two or three hours, then cooled and placed on the market.

Later, in 1906, Bohme, Much, and Romer (8) used catalase-containing material along with peroxide as a means of sterilizing but found that impurities associated with the catalase materially limited the usefulness of the two chemicals. This method could not be applied in the following years to any extent in any part of the world because the chemical industry was not yet able to supply a peroxide of high stability, high concentration, and of such a degree of purity as public health officials require for chemical products used in foodstuffs.

A common defect often encountered by cheesemakers is nissler fermentation. This fermentation results either from over-ripe and dirty milk or from contamination through unclean utensils. To overcome this difficulty in manufacturing Swiss cheese, pasteurization has been used to a limited extent to control these types of fermentations but the results have not been satisfactory. In 1927, Matheson, Boyer and Warren (10) studied the effect of various forms of oxygen in the treatment of milk to check gassy and abnormal fermentation in Swiss cheese. They reported that ozone and oxygen have a somewhat similar effect in checking gassy fermentation in Swiss cheese caused by sporeforming anaerobes. The oxygen treatment brought favorable results by checking nissler fermentation, and the action of oxygen seemed germicidal as well as inhibitory.

In 1940, Curran, Evans, and Leviton (11) investigated the sporicidal action of hydrogen peroxide and the use of crystalline catalase to dissipate residual peroxide. From their observations they reported that the appearance and odor of milk sterilized by peroxide were essentially the same as those of raw milk and that its flavor initially was only slightly inferior to that of raw milk if the treated milk was heated up to 80°C. for 15 minutes immediately

after peroxide treatment. The pH concentration of the reagent and the concentration of exposed organisms were important factors influencing the sporicidal activity of hydrogen peroxide. They reported that the spores of several bacteria died in a logarithmic manner in the presence of 1% hydrogen peroxide at 50°C. and pH 6.9.

As to the effect of hydrogen peroxide on other components in milk, different articles have been written. In 1945, Payne and Foster (14) experimented in regard to the action of hydrogen peroxide on carbohydrates and reported that simple carbohydrates such as d-glucose, known to be oxidized by hydrogen peroxide, might be expected to cause more extensive oxidation and hence produce more formaldehyde. Krukovsky and Guthrie (12) in 1946 presented detailed studies about the relationship between vitamin C, hydrogen peroxide, copper and the tallowy flavor in milk. Their data showed that the rate of ascorbic acid oxidation varied inversely with the volume of hydrogen peroxide added to the milk. Further increase in the volume of hydrogen peroxide added to milk resulted in the progressive retardation of ascorbic acid oxidation and more rapid destruction of dehydroascorbic acid.

These results were supported by the observations of Steinman and Dawson (13) who concluded that the rate of dehydroascorbic acid decomposition is increased by the addition of hydrogen peroxide apparently because of the bimolecular reaction between dehydroascorbic acid and hydrogen peroxide. They concluded that an excess of hydrogen peroxide added to the milk caused a rather pleasant almond-like flavor to be developed in the samples. Its presence was restricted to the area within which the tallowy flavor was induced by copper and its intensity followed essentially the same path.

In 1945, a plant for the electrolytic production of hydrogen peroxide of 39% strength and of very high purity was operated by Montecatine Societe Generale per l 'endustria Mineraria e Chimica at Linate near Milan, Italy (9).

The product was used for the sterilization of milk in the Milan area, as a substitute for pasteurization. Rather extensive laboratory studies indicated its suitability for this purpose according to Dr. L. Moranoli's and Dr. Squatrite's investigations, who further thought "The practice probably will be extended greatly in Italy when production can be increased." A "solid" hydrogen peroxide (35% strength, 65% urea) also has been developed for milk sterilization.

In 1947 a program involving the use of hydrogen peroxide of high purity and catalase in cheese making was initiated by Armour and Company, Chicago, Illinois (unpublished material).

This research was directed by Dr. Z. D. Roundy and his first article on the potential use of hydrogen peroxide and catalase in the Dairy Industry appeared in January 1948.

PROCEDURE

A. Source of Milk:

The milk used for making the experimental cheese was received at the Utah State Agricultural Creamery. It consisted of milk produced by the Utah State Agricultural College dairy herd and the experimental farm herd, and milk obtained from patrons supplying manufacturing grademilk. In addition some rejected milk from the Carnation Condensed Milk Plant at Wellsville, Utah, was used in two trials.

B. Preparation of the vats for each lot:

Just prior to the manufacturing of the cheese the milk was cooled to 45°F or below, thoroughly mixed, standardized to 3.6% fat and then divided into three equal lots of 500-600 pounds.

Lot 1 was kept untreated and was used as a control. Lot 2 was pasteurized at 143°F for 30 minutes and lot 3 was treated with hydrogen peroxide. Treatment with hydrogen peroxide was carried out by first heating the milk to 120°F to inactivate the catalase enzyme normally present in the milk and to increase the effectiveness of hydrogen peroxide. Enough hydrogen peroxide to give a final concentration of 0.18% was added in the form of "Perone", an edible grade of hydrogen peroxide (35% H_2O_2 made by Du Pont E. I. Du Pont Company, Electrochemical Division, Elmonte, California). The Perone was diluted with 49 times its volume of cold water before being added to the milk.

The complete decomposition of the hydrogen peroxide was checked by using the hydrogen peroxide test, carried out by using approximately 9 milligrams of milk and 5 to 6 milligrams of 30% potassium iodide; the presence of hydrogen peroxide was shown by the appearance of a pink or brown color. The Paraphenylenediamine hydrochloride test as suggested by Hawk and Summerson (15) was used to determine whether or not the hydrogen peroxide

had been decomposed; 2 to 3 drops of 2% aqueous solution of Paraphenylenediamine hydrochloride were added to approximately 10 to 15 ml. of milk. When hydrogen peroxide was present a blue color was produced immediately upon shaking the mixture or after allowing it to stand for a few minutes. When present, hydrogen peroxide may be detected by this test in the proportion of 1:40,000.

C. Manufacture for each vat:

All cheese were made by using one percent starter prepared from a pure culture of Streptococcus lactis. A setting temperature of 86°F was used. The clock method of Wilson (16) was followed for the remainder of the manufacturing procedure. The yield of each lot of milk was calculated on the basis of the pounds of cheese produced per 100 pounds of milk when taken out of the press the following day.

D. Analysis of the milk:

Samples of milk were obtained for chemical and bacteriological analysis from each lot before the addition of the starter. The analyses for the fat test, for titratable acidity, and the phosphotase test on pasteurized milk were done according to the standard methods for examinations of dairy products (9) and the pH determinations were conducted electromatically using a Beckman type G, pH meter, a type E glass electrode. The total bacterial counts were made according to standard methods. The dilutions ranged from 1/100 to 1/10,000; tryptone glucose extract agar was used as the media. Incubation temperatures of 37°C for 24 hours and 48 hours were employed. At the end of these respective incubation periods plates were counted, use being made of a magnifying lens 2½ inch diameter and Quebec colony counter.

The direct method plating was employed for detecting the coliform group; red bile agar and desoxycholate agar were used as a media on 1 ml. of samples and 1/10 ml. dilutions.

To detect the aerobic sporeformers, samples were heated to 80°C for 3, 5, and 10 minutes after heating plates were prepared using 1 ml. samples of whole milk and 1/10 aqueous dilutions of whole milk for each sample to be tested; the plating medium used was nutrient agar.

A qualitative determination was applied to detect the presence of the anoerobic sporeformers. The method of Hastings and McCoy (19) for the use of reduced iron in the cultivation of anerobic sporeformers was used. It consisted of pouring 9 ml. of fresh skim milk into sterile tubes, then adding 0.1 gm. of iron and steaming the mixture for three respective periods at 100°C for one half hour. One ml. of samples was poured into the tube, covered with a film of paraffin and incubated at 37°C for 48 hours. A gassy fermentation denoted the presence of the anoerobic sporeformer groups.

E. Analysis of the cheese:

The fat was analyzed by the Babcock method (17).

A rapid new method to determine the moisture content was applied by using the Brabender semi-automatic moisture tester (18) (Brabender and Cooperation, Rocelle Park, New Jersey) using 10 gm. of cheese sample kept at 130°F for 50 minutes. The pH was determined by using the same type of pH meter used for milk.

The protein degradation was measured by determining the total and water soluble nitrogen.

Serum: In obtaining the material used for the chemical analysis of the nitrogenous decomposition in the cheese, a procedure quoted directly from the A.O.A.C. official method and modified by Dr. Sommer (unpublished) was employed; this method briefly consisted of weighing accurately 25 gm. of the cheese sample and transferring them into a Waring type blender; 5 gm. of sodium citrate and 250 ml. of water at 50°C were added, then the mixture was subjected to high speed and stirred for 15 minutes until the

cheese had been completely suspended to produce a milky solution. The milky cheese solution was transferred to a 500 ml. beaker using 50 ml. of water at 50°C to rinse the blender vessel. To the cheese solution in the beaker, 2N acetic acid was added slowly to bring the reaction to pH 4.7. After the desired reaction had been established the solution was warmed up to 50°C in a water bath and filtered through cotton. Washing operation with distilled water at 50°C was repeated three times. The filtrate was collected into a 500 ml. volumetric flask and the solution was brought up to a volume of exactly 500 ml. Fifty ml. aliquot of the original 500 ml. filtrate were measured into a Kjeldahl flask and the modified Kjeldahl-Gunning-Arnold method, recognized as "official" by A.O.A.C., was used for the digestion (20).

F. Examination and scoring of the cheese:

The cheese was examined for flavor, body, and texture and graded twice at the age of 10 days and 2 months of ripening with criticisms. The grading was done by a Federal cheese grader.

RESULTS AND DISCUSSION

The study covers data on experiments of eleven batches of cheese made each from raw, pasteurized and hydrogen peroxide treated milk.

An examination of the data shows that the fat content varied from 3.5% to 4.1% (appendix) with an average of 3.6% (table 1).

The titratable acidities of the raw milk ranges from 0.145% to 0.18%; from 0.145% to 0.18% in the pasteurized milk and from 0.145% to 0.192% in the hydrogen peroxide treated milk. The average titratable acidities of all vats were 0.162%, 0.157% and 0.160% respectively for the raw, pasteurized and hydrogen peroxide treated milk. The manufacturing data (appendix) showed a higher acid development in raw milk than in pasteurized milk; hydrogen peroxide treated milk was intermediate in acid development. Consequently it may be asserted that the addition of 0.18% of hydrogen peroxide checks the acid development as compared with raw milk and permits keeping milk in better conditions of freshness.

The pH noted was within normal range in practically all cases. The average pH values as shown in table I were respectively 6.62, 6.64 and 6.63 in raw, pasteurized and hydrogen peroxide treated milk.

EFFECT OF HYDROGEN PEROXIDE ON THE BACTERIAL COUNT

There was considerable variation in the bacterial count of the milk. The data in table I shows an average count of 441,692; 5,223 and 6,172 for the raw, pasteurized and hydrogen peroxide treated milk respectively.

From the bacteriological results tabulated the effectiveness of the treatment of milk with 0.18% "Perone" was definitely shown. According to the experimental results presented in table I the reduction of the bacterial content attained 98.6% with hydrogen peroxide treated milk compared with 98.8% reduction in pasteurized milk. It required a very small quantity of Perone to reduce the bacterial content comparable to pasteurization.

Some of the results in experiments 5 and 9 (appendix) showed that when the milk was highly contaminated with bacteria a reduction of 99.7% in the treated milk was secured.

EFFECT OF HYDROGEN PEROXIDE ON THE COLIFORM ORGANISMS

The results tabulated show the effectiveness of hydrogen peroxide treatment on the coliform organisms. The average data of table I show a tremendous reduction in count ranging from 4,339 to 10 and 4 respectively in raw, pasteurized and hydrogen peroxide treated milk, which indicates a destruction of 99.9% of the Coli-Aerogenes present in raw milk.

The formation of gas holes is one of the common defects of cheddar cheese. The organisms responsible for the defect usually belong to the Escherichia-Aerobacter or Coliform group. The treatment seemed to have a bactericidal effect with regard to coliform organisms. In some instances the lactose fermenting yeasts have been involved (experiments 7 and 10) as well as many other organisms destroyed by hydrogen peroxide.

Table 1. Average results of analysis of milk designed for the manufacturing of cheddar cheese

Experiments 1 to 11

Kind of analysis	Type of milk		
	Raw	Pasteurized	Hydrogen peroxide
Percent fat	3.6	3.6	3.6
Percent titratable acidity	0.162	0.157	0.160
pH	6.62	6.64	6.63
Total bacterial count	441,692	5,235	6,172
Coliform	4,339	10	4
Aerobic sporeformers	1,730	88	68
Anaerobic sporeformers	5 Ferment.	2 Ferment.	None

EFFECT OF HYDROGEN PEROXIDE ON THE AEROBIC-SPOREFORMER ORGANISMS

The data presented in table 1 show that the average number of the aerobic sporeformer organisms found in raw, pasteurized and hydrogen peroxide treated milk was respectively 17,388 and 68 which indicated that the treatment with "Perome" in connection with heat had reduced the count of the aerobic sporeformer organisms to a great extent. The intensity of this reduction depended upon the length of exposure, the temperature being constant. The sporicidal effect of the combination of peroxide and heat (80°C for 3, 5, and 10 minutes) was greater than that of heat alone. This fact is brought out in table I which showed a reduction of 60.6%.

EFFECT OF HYDROGEN PEROXIDE ON THE ANAEROBIC SPOREFORMER ORGANISMS

As it is shown in table I the qualitative tests on anaerobic sporeformer types were mostly negative; while five cases of fermentation occurred in raw milk under anaerobic conditions only two cases appeared with pasteurized milk and none with the hydrogen peroxide treatment. The growth of heat resistant anaerobic sporeforming organisms which normally predominate after pasteurization, was inhibited by the treatment with 0.18% of hydrogen peroxide "Perone".

Most vegetative cells of anaeobic bacteria are very sensitive to oxygen and it has been assumed since such organisms lack catalase enzyme, that peroxide accumulates in the media under anaerobic conditions and kills the organisms.

While we are not as yet prepared to make any statements concerning the bactericidal effect of hydrogen peroxide on pathogens, it may be noted that the preliminary results have encouraged us to believe that it will be found

to have a destructive effect on these harmful organisms.

The explanation for the lethal effects of hydrogen peroxide is not so simple. Some theories by Porter (21) are involved in the bacteriostatic and germicidal properties of hydrogen peroxide whether its direct toxic effect acts upon the cell membrane, changes the physical and chemical state of the protoplasm, affects the activities of the cellular enzymes, or that of liberation of oxygen and change in oxidation reduction potential.

Although these theories are likely involved, to what extent chemical reaction and nascent oxygen take part is not clear.

It has been believed, according to Rogers and associates (22), that any substance toxic to bacteria by virtue of a chemical effect on the protoplasm will probably react with some of the ingredients of milk to which it is added. The toxic oxidizing action of H_2O_2 is never as effective in milk as in water. It has been advocated as an emergency preservative for milk intended for food because small quantities would not be injurious to the consumer since it breaks down entirely to water and molecular oxygen by the action of the catalase enzyme present normally in milk or added in other forms. The function of the catalase enzyme was that of a catalyst accelerating the velocity of the breaking down of hydrogen peroxide into molecular oxygen and water.

EFFECT OF HYDROGEN PEROXIDE ON THE FLAVOR AND THE APPEARANCE OF THE MILK

During the manufacturing process no oxidized flavor in the milk was noted when hydrogen peroxide was used in the proper concentration at the rate of 0.18%; however the peculiar flavor and smell of hydrogen peroxide were quite noticeable. Considerable foam was formed when the hydrogen peroxide was first added, and the foaming increased markedly when the

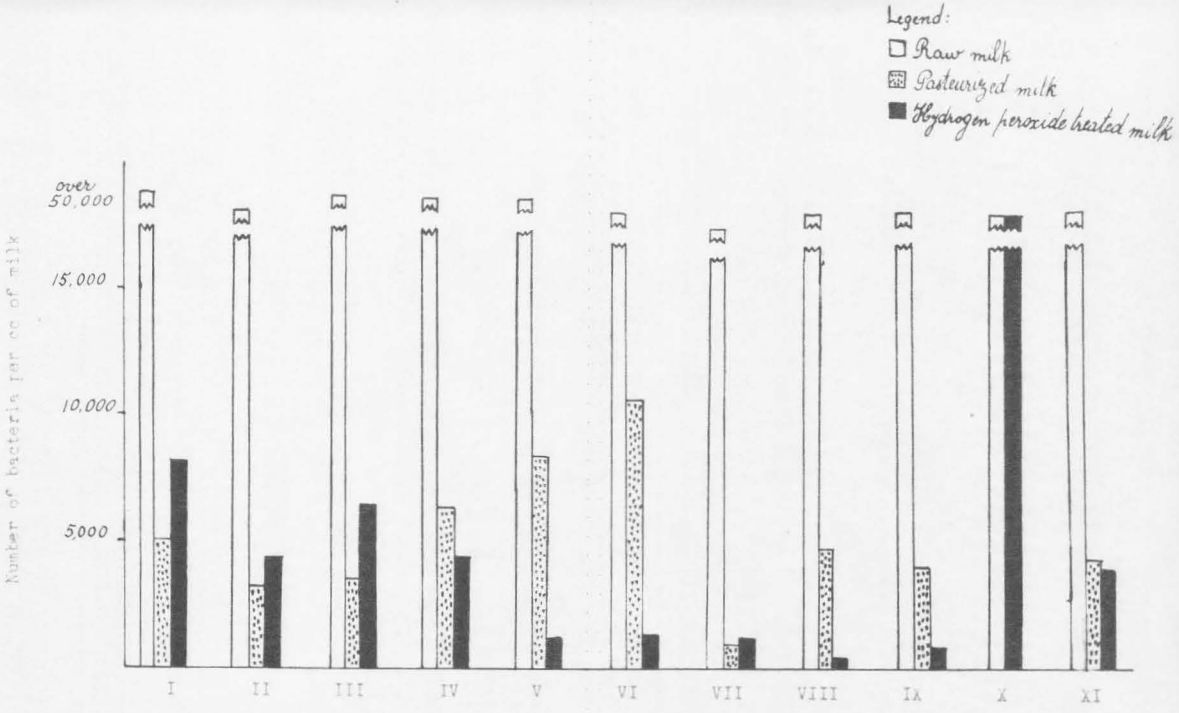

Figure 1. Effect of different treatments on bacterial content of milk. (Roman numerals denote numbers of specific experiments.)

catalase enzyme was applied. The odor and flavor of hydrogen peroxide tended to disappear gradually as the treatment was completed.

EFFECT OF HYDROGEN PEROXIDE ON THE COAGULABILITY

As to the influence of hydrogen peroxide on the coagulability of the milk, it was noted that during the manufacturing process the hydrogen-peroxide-treated milk tended to coagulate more slowly than raw and pasteurized milk after rennet was added. The retarding action upon curdling caused by hydrogen peroxide may be connected with the hydration property of the proteins and other constituents of the milk to retain more moisture.

THE EFFECT OF HYDROGEN PEROXIDE ON THE CURD DURING THE MANUFACTURING

The protein and probably some other constituents of the milk showed a great affinity for water following the treatment with peroxide. This hydration property caused a highly hydrated curd. From the experimental results shown in the manufacturing report (appendix) the highly hydrated curd suggested as a possible factor affecting the acidity of the vat at cooking, dipping and milling and so far the quality of the cheese while the cheese curd was matting in the vats, it generally was possible to observe that the treated curd retained more moisture and the stringy character of the meat chicken breast was not so characteristic as in raw milk cheese. As the time approached for salting the curd of the treated cheese the cheese developed a more pronounced odor of cheddar cheese.

The cheese was analyzed chemically at least 10 days after manufacturing. Statistical averages of data are presented in table 2 showing the percentage of chemical analysis in the comparative study.

The average percentages of the fat content were respectively 31.90%, 32.30% and 30.80% in raw, pasteurized and hydrogen-peroxide-treated milk. The fat content of the pasteurized milk cheese was higher than in raw milk cheese and the fat content of the hydrogen-peroxide-treated milk was considerably lower than that of the raw and pasteurized milk cheese. The decrease in percentage of fat in the hydrogen-peroxide-treated milk cheese was mainly due to the high moisture content that modified the weight of the samples. The lower fat content did not indicate any relationship to the quality of the cheese.

The moisture content was the main factor that had influenced the final quality of the cheese. The data in which the experiments involved excessive variations are shown in the percentage of moisture content. The moisture content as shown in the tables 5, 7, and 9 (appendix) ranged respectively from 32.40%, 32.80%, 37.7% to a maximum 39.30%, 39.70% and 43.30% in raw, pasteurized and hydrogen-peroxide-treated milk cheese with an average of 34.85%, 36.13% and 39.37%. The results seem to indicate quite definitely that the wide variations in the hydrogen-peroxide-treated milk could be attributed to the imbibing properties of hydrogen peroxide. Consequently the high moisture content had a detrimental effect on the scores. The data show that all the treated milk cheese were high in moisture compared to raw and pasteurized milk cheese and that it did affect appreciably the quality of the cheese by producing an objectionable flavor of high acid and slight bitterness, and a weak body was evident. This unfavorable influence of the high moisture content may be overcome by cooking at higher temperatures which tends to dry the cheese in the vat by a sufficient rate and amount of drainage and low temperature storage (34°F). The data in table 2 show an increased final acidity, a low pH value in the treated milk cheese as compared with that of raw and pasteurized milk cheese.

Table 2. Average results of analysis of cheddar cheese

Experiments 1 to 11

Kind of analysis	Type of milk		
	Raw	Pasteurized	Hydrogen peroxide
Percent fat	31.90	32.30	30.80
Percent moisture	34.85	36.13	39.37
pH	5.02	5.08	5.01
Percent total nitrogen	3.92	3.90	3.65
Percent water soluble nitrogen	0.389	0.316	0.402
Yield per 100 pounds	9.8	10.13	11.03

The average pH values for the cheese at 10 days of age were 5.02, 5.08, and 5.01 respectively in the raw, pasteurized and hydrogen peroxide treated milk cheese. Two factors may cause the fact of the high acid (1). A high moisture content favored the acid development which increased considerably after the manufacturing and led to excessive fermentation especially when inferior quality milk was used. (2) Use of 1% starter

EFFECT OF HYDROGEN PEROXIDE ON THE PROTEIN DEGRADATION OF THE CHEESE

Comparison of the data obtained from analyzing the cheese for protein degradation indicates a variation in the nitrogenous content. The analytical results in table 2 show an average of 3.92, 3.90 and 3.65% for total nitrogen and 0.389, 0.316 and 9.402% for water soluble nitrogen. The total nitrogen content differed within narrow limits and was reasonably uniform for all samples except the slight decrease in the treated cheese samples. The average analysis made on the treated milk cheese for protein degradation calculated in terms of per cent of nitrogen water soluble, increased approximately 3.5% in water soluble nitrogen over the cheese made from raw milk and 21.2% over the cheese made from pasteurized milk. Concerning the proteolytic analysis, the ripening of the cheese is a complicated chemical and physical process and the rate of ripening is affected by many factors such as types, number and activity of organisms and enzymes, high moisture content of the cheese and the conditions under which the cheese is held during the ripening. The increase in the percentage of water soluble nitrogen may be attributed to the proteolytic enzymes and the natural hydrolytic action of the high moisture content of the cheese. The pH probably affected the protein hydrolysis too. It is evident in our experiments that the per cent water soluble nitrogen is directly proportional to the high moisture content of the cheese.

EFFECT OF HYDROGEN PEROXIDE ON THE YIELD OF THE CHEESE

The weight of the cheese brought out the fact that the yield did fluctuate with the varying moisture content and the increase in the yield of the treated milk cheese was probably due to the retention of more moisture. The gain in pasteurized milk cheese was caused by the retention of more of the fat, solids-not-fat, and moisture. The hydrogen peroxide treated milk cheese as presented in table 2 showed a gain in yield of 17% over the weight of raw milk cheese and 14% over the pasteurized milk cheese.

EFFECT OF HYDROGEN PEROXIDE ON FLAVOR OF CHEESE

It is well known that a high moisture cheese is more likely to develop a sharp flavor and that it will ripen faster than a low moisture cheese. As a matter of fact all the treated milk cheese shown in table 9 (appendix) were high in moisture as compared to raw and pasteurized milk cheese and that it did affect appreciably the quality of the cheese by producing an objectionable flavor of high acid and slight bitterness with an average score of 38.1 compared with 37.2 for raw milk cheese and 38.6 for pasteurized milk cheese (table 3). From an analysis of the data shown in table 3 together with the criticisms made of each lot, the significant results from the use of hydrogen peroxide in the treated milk were shown in the flavor scores and comments. The pasteurized milk cheese scores showed an average variation of 1.15 points over the raw milk cheese, and 0.5 points over the treated milk cheese. Apparently the heat treatment exercised certain control over the factors which caused the decline in the quality of raw milk cheese.

When low grade milk was used (experiments 4, 10, and 11) the cheese made from treated milk and pasteurized milk were consistently better and more uniform in quality than raw milk cheese; however, with high grade milk

the raw and the treated milk ripened and acquired flavor more rapidly than the pasteurized milk cheese.

The tendency toward high acid and bitterness in the hydrogen peroxide cheese is chiefly attributed to the high moisture content which activates the bacterial growth and the chemical changes. The use of an initial high percentage of starter might be one cause of this condition.

EFFECT OF HYDROGEN PEROXIDE ON THE BODY AND TEXTURE

The effect of hydrogen peroxide in treating milk had a marked influence on the body and texture of the cheese. Typical cheddar cheese has a compact texture and a waxy firm body. A defect of soft, weak and pasty body predominated in the 80% of the experiments as shown in table 3, producing an average score of 28.2 as compared with 28.5 in pasteurized milk cheese and 27.5 in raw milk cheese. In two cases (experiments 4 and 10) the treated milk cheese showed a tendency to gassiness but more often undesirable fermentations were in evidence in the raw milk cheese. These fermentations could be prevented by the use of higher percentages of hydrogen peroxide. In general a rather weak body resulted in the cheese made with hydrogen-peroxide treated-milk. The explanation to this characteristic was due to the increased moisture content of the hydrogen peroxide cheese. More bound or free moisture was held in the curd.

It is evident that too much acidity in high moisture curd at time of draining and milling causes a defect of a weak and pasty body. To overcome this defect cooking sufficiently at higher temperatures or increasing the length of cooking time may be suggested.

During the scoring the plug of the treated milk cheese could be bent considerably and was springy; but when a piece of the plug was pressed between the fingers a rather pasty body was noticeable. An uneven shape

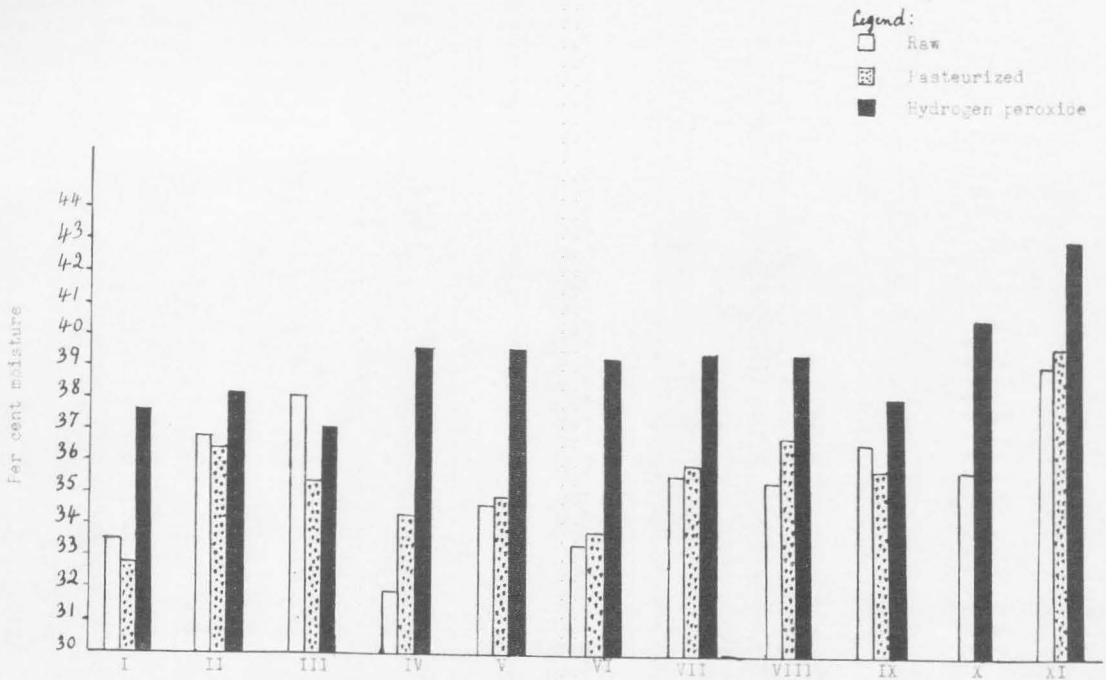

Figure 2. Effects of different treatments on the moisture content of cheese. (Roman numerals denote numbers of specific experiments.)

Table 3. Data showing scores on flavor, body and texture with comments and criticisms at 1 month of age

Exp. No.	Raw				Pasteurized				Hydrogen Peroxide			
	Fla. Score	Comments & Criticisms	B & T Score	Comments & Criticisms	Fla. Score	Comments & Criticisms	B & T Score	Comments & Criticisms	Fla. Score	Comments & Criticisms	B & T Score	Comments & Criticisms
I	38	high acid	28	scattered pin holes	38.5	slight acid meaty	28.5	scattered pin holes	38.5	high acid	29.5	weak
II	37	fermented and fruity	28		39	mitty flavor	28.5	scattered sweet holes	39	slight acid	28.5	soft
III	39	fermented and high acid	27.5	corkey and open	39	slightly bitter	28	open	38	high acid	27.5	open
IV	39	flat	27.5	open and corkey	38	bitter slight acid	28	open and weak	38.5	slight acid and slight bitter	27.5	open
V	38	fermented fruity sour whey flavor	28	open firm body	39.5	sweet flavor	28	scattered sweet holes & slight gassiness	39	slight acid	28	scattered holes, weak
VI	38	fruity	28	open scattered sweet holes	39.5	slight acid	28.5	open	38	slight acid	28.5	scattered sweet holes
VII	36	strong fermented fruity unclean	27	slightly open	38.5	slight acid	29	slight open	39.5	slight acid	29.5	
VIII	38	slightly fermented whey flavor	28.5	open	38.5	acid	29	slightly open	39	slight acid touch of bitterness	29.5	
IX	38.5	high acid and fermented	28	open short	39.0	clean flaw high acid	29.5		38	high acid slightly bitter	28.5	
X	34	yeasty unclean	25	curdy					36	fruity high acid	26	pasty scattered holes
XI	34	yeasty unclean gassy	24	crumbly	37	slight acid	28.5	open slightly curdy	37	high acid fruity	27.5	scattered holes and pasty
Average scores with majority of comments & criticisms		37.2 fermented	27.2	open scattered sweet holes	38.6	slight acid	28.5	slightly open	38.1	high acid	28.2	weak body

and rough edges resulting from the weak body appeared in the treated cheese when taken out of the press.

All solutions proposed for the sterilization of milk have to consider that the cost of processing milk must not rise too high. This point of view is of prime importance. The cost of equipment, the extra labor required in pasteurization as well as the production of hydrogen peroxide and catalase are all variable factors in the total cost. In general, pasteurized milk for cheddar cheese making has been discouraged in small plants due to the cost of equipment and the extra labor. As a matter of fact the usual type of pasteurizing machinery of sufficient capacity to meet the needs of the factories would cost a large part of the total investment. As to the cost of pasteurization it takes approximately four pounds of steam per 100 pounds of milk regardless of the type of pasteurizer. This interpreted into dollars and cents, based on $5.00 coal, is the equivalent of 1½ cents per 100 pounds of milk. There is also some additional electricity involved, the amount of which is somewhat dependent on the size of the pasteurizer. The cost would range from about 4/10 to 5/10 of a cent per 100 pounds of milk based on 3 cents per kilowatt hour. Aside from this, there is approximately two to four additional man hours per day, cleaning up the pasteurizer and so forth calculated at 0.015 cents per 100 pounds Sammis (20); water at $1.00 per 1000 cu. ft. or $0.183 per 100 pounds, 10% annually depreciation; per day $0.183 per 100 pounds. All things together will total $.22 per 100 pounds.

On the other side the following figure represents the cost of hydrogen peroxide-catalase treatment in our experiments based on 100 pounds of milk.

Hydrogen peroxide "Perone" at 0.60 cents a pound and the amount used is .18%; therefore it was calculated at $.108 per 100 pounds.

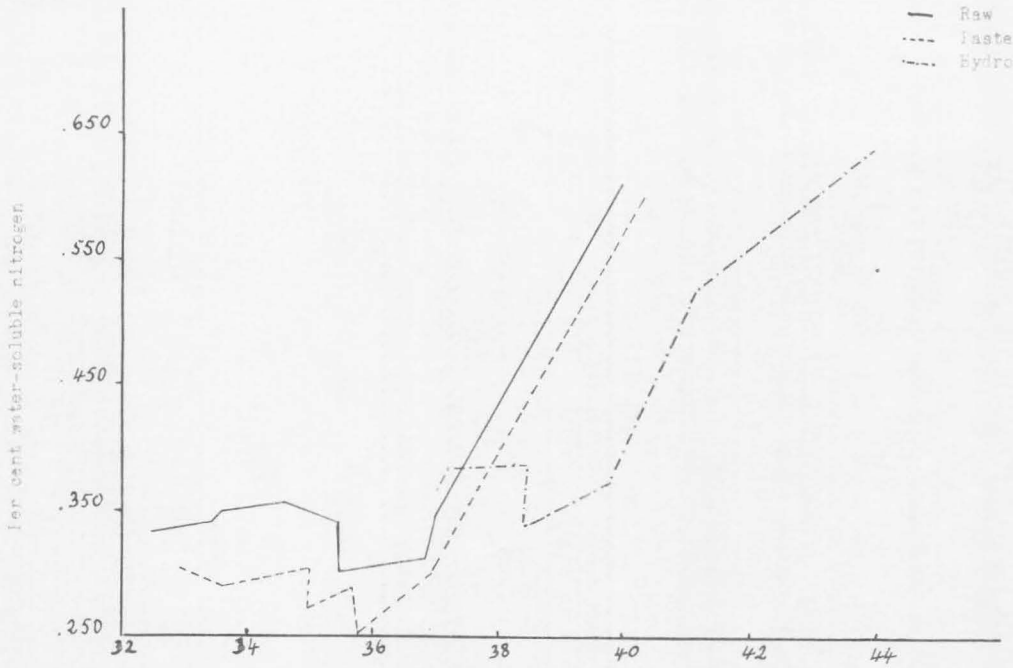

Figure 3. Relationship between moisture content of cheese and percentage of water-soluble nitrogen. (Roman numerals denote numbers of specific experiments.)

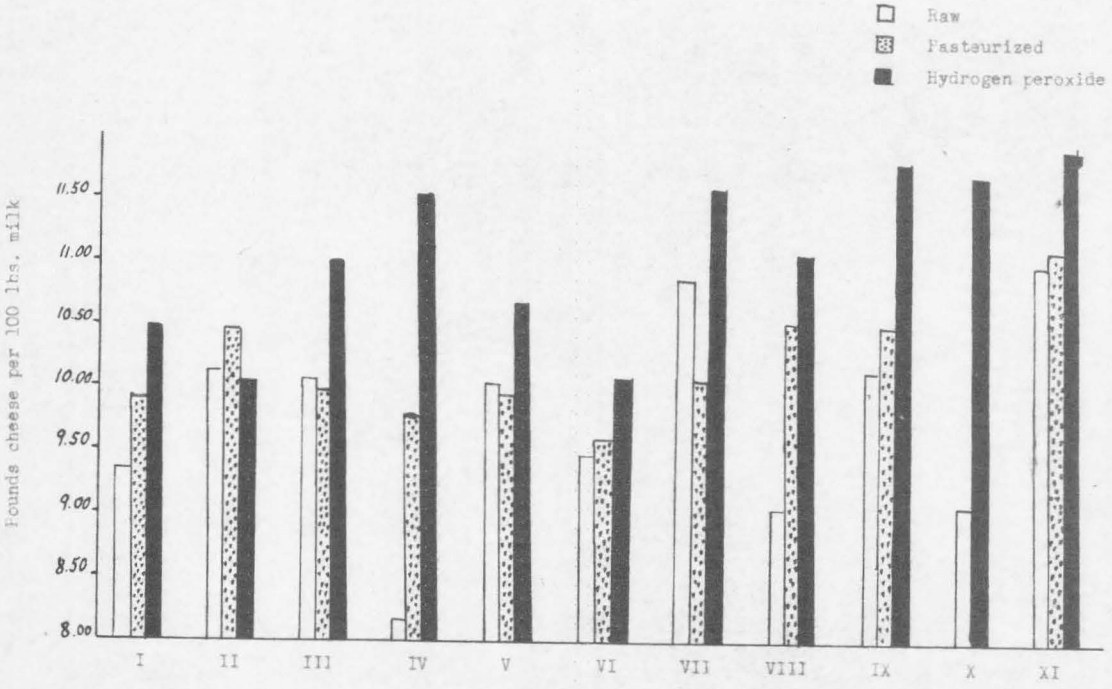

Figure 4. Effects of different treatments on yield of cheese. (Roman numerals denote numbers of specific experiments.)

The Catalase at $1.00 a pound was in a paste form and the amount used was 8% of the amount of hydrogen peroxide calculated at $.015 per 100 pounds of milk. Heat and power to bring the temperature up to 120°F. can be evaluated at 2 cents per 100 pounds all together totaling $.126.

From this figure it can be said that the treatment of milk with hydrogen peroxide represents a remarkable economy of $.074 per 100 pounds as compared with the thermal process of pasteurization.

CONCLUSIONS

The series of experiments using hydrogen peroxide and catalase were based largely on limited previous experimental work and on a very few scattered reports in the literature. From the results of this series of experiments it would be a mistake to look upon hydrogen peroxide and catalase as a panacea or cure-all. Neither is it intended that hydrogen peroxide-catalase treatment of milk be a substitute for a quality program in cheese making any more than pasteurization is. However, hydrogen peroxide appears to have many possibilities especially where pasteurization is not feasible.

From the results obtained in this project the following conclusions may be listed:

1. The hydrogen peroxide treatment successfully reduced the bacterial count including coliform organisms, aerobic and anaerobic sporeformer organisms.
2. The treatment with hydrogen peroxide caused greater retention of moisture in the curd and the finished cheese. This retained moisture increased the yield of the water soluble nitrogen and shortened the time of ripening. However, it caused defects such as high acid, bitterness, weak and pasty body, and consequently a poor pressing ability which is very objectionable in commercial cheese.
3. To overcome defects due to high moisture, some adjustments can be suggested during the making process.
    a. The cooking temperature can be raised two or three degrees and the cooking time may be increased.
    b. A more prolonged cheddaring to drain off the whey if necessary.

4. Treatment of milk with hydrogen peroxide seems to offer some advantages from the practical and economical point of view by reducing the bacterial centers in the milk, especially in the Middle East where refrigeration facilities are not usually available. It is economical because if the milk is treated on the farm it would permit a transportation for a considerable distance without the necessity of refrigeration or cooling. It is actually not possible to gather the milk everywhere with the rapidity which the sensitivity of the milk requires. If the practice is not contrary to American Pure Food Laws it would seem that this method may be desirable for introduction into isolated communities and rural areas where pasteurization is not feasible. It is these communities that often have common diseases occur due to consumption of unpasteurized milk.

The experimental results obtained seem sufficiently convincing to indicate that hydrogen peroxide has numerous possibilities in the dairy industry and can fulfill some of the requirements of a satisfying, economical and reasonable method of treating milk for cheese making.

SUMMARY

The project is a comparative study involving the manufacturing of cheddar cheese using raw, pasteurized, and hydrogen peroxide treated milk. Eleven lots were made and analyzed at an age of ten and thirty days to determine the bacteriological, chemical, and organoleptic effect of hydrogen peroxide on the milk designed for the manufacture and the cheese made from it. The flavor, body and texture were noted.

1. Treatment of milk with edible hydrogen peroxide "Perone" destroyed 99.9% of the coliform organisms, 98.6% of the total bacterial count and showed a negative test for anaerobic sporeforming organisms. The action of hydrogen peroxide on the microorganisms appears germicidal as well as inhibitory.
2. As the milk was being treated with hydrogen peroxide, the chemical odor and flavor was noted accompanied by a foam formation on the surface due to the evolution of oxygen. As the treatment was completed, the peroxide odor and flavor disappeared and the foaming ceased.
3. Catalase enzyme being a good antioxidant tended to prevent the development of an oxidized flavor in the treated cheese.
4. The treated milk showed a lower acidity at the time of adding the starter compared to raw milk.
5. The proteins and probably some other constituents of the milk showed an affinity for water following the treatment of hydrogen peroxide. This hydration property caused the following characteristics in the cheese made from the treated milk:
   a. A slower thickening of the milk when rennet was added
   b. A highly hydrated curd which resulted in a high moisture content and increased the yield.

c. A flavor defect of high acid and slight bitterness

d. A weak and pasty body.

6. The retention of the bound moisture into the curd increased the water soluble nitrogen. The total nitrogen remained constant.

7. Cheese made from hydrogen peroxide-catalase treated milk appear to ripen faster and have a more pronounced flavor than pasteurized milk cheese. This may be due in part to the more complete destruction of objectionable organisms by hydrogen peroxide less complete destruction of the enzymes indigenous to the milk and to the fact that many of the off flavors in the milk escape during the intense foaming that occurs when hydrogen peroxide is decomposed by the catalase enzyme.

8. Gassy milk treated with hydrogen peroxide produced cheese of better quality than if raw milk was used.

APPENDIX

Table 4. Results of chemical and bacteriological analysis of raw milk

Lot number	Percent fat	Percent titratable acidity	pH	Total bacterial count	Coliform	Aerobic spore-formers	Anaerobic spore-formers
1	3.6	0.190	6.51	132,000	3,550	300	Positive
2	4.1	0.170	6.62	17,350	5,800	365	Negative
3	3.8	0.165	6.63	60,260	4,400	182	Negative
4	3.5	0.165	6.61	170,000	3,500	310	Positive
5	3.6	0.160	6.62	400,000	18,000	175	Negative
6	3.6	0.150	6.68	175,000	4,300	30	Positive
7	3.6	0.155	6.62	150,000	3,508	48	Negative
8	3.6	0.160	6.68	136,000	4,500	73	Negative
9	3.6	0.160	6.67	450,500	4,580	50	Negative
10	3.6	0.145	6.64	3,000,000	4,800	249	Positive
11	3.6	0.170	6.58	168,000	7,000	35	Positive

Table 5. Results of chemical analysis of the raw milk cheddar cheese

Lot number	Percent fat	Percent moisture	pH	Percent total nitrogen	Percent water Sol. Nit.	Yield per 100 pounds
1	32.50	33.50	4.95	3.82	0.340	9.4
2	32.10	36.80	5.03	3.86	0.138	10.2
3	30.80	38.20	5.08	3.71	0.393	10.15
4	32.40	32.40	4.98	4.00	0.322	8.2
5	32.10	34.70	5.05	3.85	0.352	10.0
6	32.30	33.40	5.15	4.10	0.336	9.4
7	31.00	35.60	5.00	4.00	0.306	10.8
8	32.60	35.60	4.91	3.98	0.334	9.13
9	32.00	36.90	5.10	3.70	0.344	10.19
10	31.10	35.80	5.15	4.24	0.616	9.14
11	30.10	39.30	4.95	4.09	0.628	10.8

Table 6. Results of chemical and bacteriological analysis of pasteurized milk

Lot number	Percent fat	Percent titratable acidity	Phosphotase test	pH	Total bacterial count	Coliform	Aerobic spore-formers	Anaerobic spore-formers
1	3.6	0.180	Negative	6.63	5,067	none	140	Negative
2	4.1	0.160	Negative	6.64	3,000	10	220	Negative
3	3.8	0.160	Negative	6.65	3,280	none	80	Negative
4	3.5	0.160	Negative	6.63	6,200	73	250	Positive
5	3.6	0.155	Negative	6.66	9,300	2	50	Negative
6	3.6	0.145	Negative	6.68	11,000	9	30	Positive
7	3.6	0.145	Negative	6.68	1,350	1	15	Negative
8	3.6	0.150	Negative	6.68	4,725	8	10	Negative
9	3.6	0.150	Negative	6.69	3,600	none	60	Negative
10	3.6	0.165	Positive	6.61	4,800	2	16	Negative

Table 7. Results of chemical analysis of pasteurized milk cheese

Lot number	Percent fat	Percent moisture	pH	Percent total nitrogen	Percent water Sol. Nit.	Yield per 100 pounds
1	32.65	32.80	5.10	3.89	0.304	9.8
2	32.30	36.50	5.12	3.80	0.304	10.5
3	33.50	35.50	5.04	3.50	0.290	10.10
4	32.50	34.90	4.99	4.01	0.276	9.8
5	32.50	34.90	5.10	4.12	0.256	9.8
6	32.50	33.55	5.15	3.92	0.289	9.6
7	31.50	35.80	5.10	3.95	0.250	10.12
8	32.70	36.80	5.11	4.00	0.304	10.6
9	32.60	35.80	5.11	3.69	0.286	10.22
10	30.40	39.70	4.98	4.12	0.598	10.9

Table 8. Results of chemical and bacteriological analysis of hydrogen peroxide treated milk

Lot number	Percent fat	Percent titratable acidity	pH	Total bacterial count	Coliform organisms	Aerobic Spore-forms	Anaerobic Spore-forms
1	3.6	0.192	6.50	8,247	none	210	Negative
2	4.1	0.165	6.63	4,200	13	100	Negative
3	3.8	0.160	6.64	6,600	1	55	Negative
4	3.5	0.160	6.63	4,200	13	165	Negative
5	3.6	0.158	6.64	1,200	none	50	Negative
6	3.6	0.150	6.678	1,350	none	10	Negative
7	3.6	0.150	6.67	2,030	none	10	Negative
8	3.6	0.160	6.67	1,225	6	10	Negative
9	3.6	0.155	6.60	3,850	none	12	Negative
10	3.6	0.145	6.65	31,000	142	125	Negative
11	3.6	0.170	6.60	4,000	none	11	Negative

Table 9. Results of chemical analysis of hydrogen peroxide treated milk cheese

Lot number	Percent fat	Percent moisture	pH	Percent total nitrogen	Percent water Sol. Nit.	Yield per 100 pounds
1	31.50	37.60	5.00	3.70	0.374	10.5
2	30.80	38.20	5.08	3.71	0.393	10.15
3	31.80	37.20	4.94	3.39	0.366	11.10
4	30.70	39.80	4.95	3.74	0.393	11.6
5	30.80	39.70	4.96	3.67	0.304	10.45
6	30.80	39.45	5.11	3.70	0.332	10.2
7	30.50	39.50	4.99	3.79	0.372	11.43
8	31.80	39.50	5.02	3.66	0.384	11.2
9	31.20	38.20	5.00	3.58	0.348	11.14
10	30.40	40.75	5.15	3.50	0.513	11.75
11	29.60	43.30	4.91	3.81	0.656	11.84

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment I Date 7-11-48

	VAT 1	VAT 2	VAT 3
eatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.6%	3.6%	3.6%
ethylene blue of raw milk			
arter quality			
ilk quality	Good	Good	Good
mount of milk	450 pounds	450 pounds	450 pounds
rcent of starter added	1%	1%	1%
mount of starter	4.5 pounds	4.5 pounds	4.5 pounds
mount of color	20 cc	20 cc	20 cc
mount of salt	18 ounces	18 ounces	18 ounces
cidity of starter	.74%		
cidity of milk	.190%	.18%	.192%
cidity after starter was added	.190%	.18%	.192%
cidity when rennet was added	.20%	.185%	.192%
cidity of whey at cutting	.12%	.11%	.123%
cidity of whey at dipping	.13%	.13%	.15%
cidity of whey at packing			
cidity of whey at milling	.52%	.50%	.51%
me of adding starter	10:10	12:20	11:30
me of adding rennet			
me of cutting			
me steam on	The clock method followed		
me steam off			
me dipped			
me milled			
me salted			
me hooped			
me dressed			
mperature of starter	68°F	68°F	68°F
mperature of setting	86°F	86°F	86°F
mperature of cooking	101°F	101°F	101°F
mperature of hooping	93°F	93°F	93°F
H at cutting	6.5	6.55	6.45
H at dipping	6.2	6.50	5.95
H at milling	4.5	5.00	4.6
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
rcent moisture			
rcent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment II Date 7-12-48

	VAT 1	VAT 2	VAT 3
eatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk			
ethylene blue of raw milk	4.1%	4.1%	4.1%
arter quality			
ilk quality	Good	Good	Good
mount of milk	500 pounds	580 pounds	500 pounds
ercent of starter added	1%	1%	1%
mount of starter	5 pounds	5 pounds	5 pounds
mount of color	15 cc	17 cc	15 cc
mount of salt	20 ounces	23 ounces	20 ounces
cidity of milk	.17%	.16%	.165%
cidity after starter was added			
cidity when rennet was added	.18%	.17%	.17%
cidity of whey at cutting	.139%	.11%	.12%
cidity of whey at dipping	.15%	.13%	.14%
cidity of whey at packing	.41%	.35%	.35%
cidity of whey at milling	.48%	.42%	.42%
me of adding starter	12:15	12:15	12:15
me of adding rennet			
me of cutting			
me steam on	The clock method followed		
me steam off			
me dipped			
me milled			
me salted			
me hooped			
me dressed			
mperature of starter	60°F	60°F	60°F
mperature of setting	86°F	86°F	86°F
mperature of cooking	101°F	101°F	101°F
mperature of hooping	95°F	95°F	95°F
H at cutting	6.5	6.66	6.49
H at dipping	6.36	6.40	6.30
H at milling	5.28	5.1	5.02
H one week old			
pe of cheese made		Cheddar	
eld per cwt. of milk			
eld per pound of fat			
rcent moisture			
rcent fat			
ore of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment III Date 7-13-43

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.8%	3.8%	3.8%
ethylene blue of raw milk			
arter quality			
ilk quality	Good	Good	Good
mount of milk	500 pounds	500 pounds	500 pounds
ercent of starter added	1%	1%	1%
mount of starter	5 pounds	5 pounds	5 pounds
mount of color	15 cc	15 cc	15 cc
mount of salt	20 ounces	20 ounces	20 ounces
cidity of milk	.165%	.16%	.16%
cidity after starter was added			
cidity when rennet was added	.17%	.16%	.16%
cidity of whey at cutting	.126%	.115%	.116%
cidity of whey at dipping	.145%	.12%	.135%
cidity of whey at packing	.33%	.29%	.31%
cidity of whey at milling	.49%	.43%	.48%
me of adding starter	12:20	11:45	11:45
me of adding rennet			
me of cutting			
me steam on	The clock method followed		
me steam off			
me dipped			
me milled			
me salted			
me hooped			
me dressed			
emperature of starter	62°F	62°F	62°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	93°F	93°F	93°F
H at cutting	6.49	6.51	6.50
H at dipping	6.40	6.45	6.20
H at milling	5.55	5.8	5.3
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment IV Date 7-14-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.5%	3.5%	3.5%
ethylene blue of raw milk			
arter quality			
ilk quality	Poor	Poor	Poor
mount of milk	400 pounds	400 pounds	400 pounds
ercent of starter added	1%	1%	1%
mount of starter	4 pounds	4 pounds	4 pounds
mount of color	14 cc	14 cc	14 cc
mount of salt	16 ounces	16 ounces	16 ounces
cidity of milk	.165%	.16%	.165%
cidity after starter was added			
cidity when rennet was added	.17%	.16%	.165%
cidity of whey at cutting	.112%	.10%	.109%
cidity of whey at dipping	.13%	.12%	.12%
cidity of whey at packing			
cidity of whey at milling	.46%	.45%	.455%
me of adding starter	11:25	12:00	12:00
me of adding rennet			
me of cutting			
me steam on	The clock method followed		
me steam off			
me dipped			
me milled			
me salted			
me hooped			
me dressed			
emperature of starter	60°F	60°F	60°F
emperature of setting	88°F	88°F	88°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	92°F	92°F	92°F
H at cutting	6.50	6.52	6.50
H at dipping	5.98	6.29	6.21
H at milling	5.3	5.1	5.1
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment V Date 7-16-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.6%	3.6%	3.6%
ethylene blue of raw milk			
arter quality			
ilk quality	Good	Good	Good
mount of milk	400 pounds	400 pounds	400 pounds
ercent of starter added	1%	1%	1%
mount of starter	4 pounds	4 pounds	4 pounds
mount of color	14 cc	14 cc	14 cc
mount of salt	16 ounces	16 ounces	16 ounces
cidity of milk	.16%	.155%	.158%
cidity after starter was added			
cidity when rennet was added	.18%	.82%	.85%
cidity of whey at cutting	.12%	.11%	.12%
cidity of whey at dipping	.145%	.13%	.12%
cidity of whey at packing			
cidity of whey at milling	.60%	.45%	.48%
me of adding starter	10:15	1:20	1:00
me of adding rennet			
me of cutting			
me steam on	The clock method followed		
me steam off			
me dipped			
me milled			
me salted			
me hooped			
me dressed			
emperature of starter	69°F	69°F	69°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	95°F	95°F	95°F
H at cutting	6.45	6.51	6.28
H at dipping	6.20	6.13	5.90
H at milling	5.17	5.50	5.48
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment VI Date 7-17-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.6%	3.6%	3.6%
lethylene blue of raw milk			
arter quality			
ilk quality	Good	Good	Good
mount of milk	540 pounds	540 pounds	540 pounds
ercent of starter added	1%	1%	1%
mount of starter	5.4 pounds	5.4 pounds	5.4 pounds
mount of color	16.2 cc	16.2 cc	16.2 cc
mount of salt	21.6 ounces	21.6 ounces	21.6 ounces
cidity of milk	.150%	.145%	.150%
cidity after starter was added			
cidity when rennet was added	.165%	.160%	.160%
cidity of whey at cutting	.10%	.095%	.10%
cidity of whey at dipping	.14%	.135%	.13%
cidity of whey at packing	.31%	.35%	.25%
cidity of whey at milling	.44%	.41%	.40%
ime of adding starter			
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	67°F	67°F	67°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	95°F	95°F	95°F
H at cutting	6.5	6.5	6.48
H at dipping	6.1	6.05	6.28
H at milling	5.2	5.25	5.25
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment VII Date 7-20-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk	3.6%	3.6%	3.6%
lethylene blue of raw milk			
arter quality			
ilk quality	Fair	Fair	Fair
mount of milk	400 pounds	400 pounds	400 pounds
ercent of starter added	1%	1%	1%
mount of starter	4 pounds	4 pounds	4 pounds
mount of color	12 cc	12 cc	12 cc
mount of salt	16 ounces	16 ounces	16 ounces
cidity of milk	.155%	.145%	.150%
cidity after starter was added			
cidity when rennet was added	.17%	.15%	.155%
cidity of whey at cutting	.11%	.10%	.105%
cidity of whey at dipping	.13%	.125%	.12%
cidity of whey at packing			
cidity of whey at milling	.38%	.39%	.40%
ime of adding starter	10:00	12:00	12:00
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	69°F	69°F	69°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	102°F	102°F	102°F
emperature of hooping	96°F	96°F	96°F
H at cutting	6.52	6.58	6.15
H at dipping	6.25	6.09	5.9
H at milling	6.0	5.7	5.2
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment VIII Date 7-21-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
t test of milk ethylene blue of raw milk	3.6%	3.6%	3.6%
arter quality			
ilk quality	Good	Good	Good
mount of milk	490 pounds	490 pounds	490 pounds
ercent of starter added	1%	1%	1%
mount of starter	4.9 pounds	4.9 pounds	4.9 pounds
mount of color	15 cc	15 cc	15 cc
mount of salt	20 ounces	20 ounces	20 ounces
cidity of milk	.160%	.150%	.160%
cidity after starter was added			
cidity when rennet was added	.170%	.160%	.165%
cidity of whey at cutting	.11%	.105%	.105%
cidity of whey at dipping	.13%	.125%	.13%
cidity of whey at packing	.39%	.40%	.45%
cidity of whey at milling	.43%	.48%	.49%
ime of adding starter	10:40	12:50	11:45
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	67°F	67°F	67°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	96°F	97°F	97°F
H at cutting	6.7	6.8	6.6
H at dipping	6.3	6.4	6.3
H at milling	5.15	5.20	5.0
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment IX Date 7-23-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
at test of milk lethylene blue of raw milk	3.6%	3.6%	3.6%
tarter quality			
ilk quality	Good	Good	Good
mount of milk	400 pounds	400 pounds	400 pounds
ercent of starter added	1%	1%	1%
mount of starter	4 pounds	4 pounds	4 pounds
mount of color	14 cc	14 cc	14 cc
mount of salt	16 ounces	16 ounces	16 ounces
cidity of milk	.160%	.150%	.155%
cidity after starter was added			
cidity when rennet was added	.170%	.160%	.160%
cidity of whey at cutting	.11%	.10%	.104%
cidity of whey at dipping	.125%	.112%	.125%
cidity of whey at packing	.32%		
cidity of whey at milling	.47%	.45%	.40%
ime of adding starter	9:15	11:00	10:40
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	70°F	70°F	70°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	101°F	101°F	101°F
emperature of hooping	94°F	94°F	95°F
H at cutting	6.31	6.30	6.30
H at dipping	6.2	6.25	6.1
H at milling	5.44	5.45	5.40
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment X Date 7-30-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw		Hydrogen Peroxide
t test of milk	3.6%		3.6%
lethylene blue of raw milk			
arter quality			
ilk quality	Rejected		Rejected
mount of milk	250 pounds		250 pounds
ercent of starter added	1%		1%
mount of starter	25 pounds		25 pounds
mount of color	7.5 cc		7.5 cc
mount of salt	10 ounces		10 ounces
cidity of milk	.145%		.145%
cidity after starter was added			
cidity when rennet was added	.145%		.145%
cidity of whey at cutting	.105%		.105%
cidity of whey at dipping	.116%		.120%
cidity of whey at packing	.28		.295
cidity of whey at milling	.392		.399
ime of adding starter	9:30		10:35
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	70°F		70°F
emperature of setting	87°F		87°F
emperature of cooking	101°F		101°F
emperature of hooping	96°F		97°F
H at cutting	6.31		6.30
H at dipping	6.26		6.25
H at milling	5.50		5.48
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

UTAH STATE AGRICULTURAL COLLEGE

Dairy Manufacturing

CHEDDAR CHEESE MAKE RECORD

aker Experiment XI Date 7-30-48

	VAT 1	VAT 2	VAT 3
reatment of Milk	Raw	Pasteurized	Hydrogen Peroxide
at test of milk	3.6%	3.6%	3.6%
lethylene blue of raw milk			
tarter quality			
ilk quality	Very poor	Very poor	Very poor
mount of milk	500 pounds	500 pounds	500 pounds
ercent of starter added	1%	1%	1%
mount of starter	5 pounds	5 pounds	5 pounds
mount of color	15 cc	15 cc	15 cc
mount of salt	20 ounces	20 ounces	20 ounces
cidity of milk	.170%	.165%	.170%
cidity after starter was added			
cidity when rennet was added	.178%	.170%	.175%
cidity of whey at cutting	.115%	.110%	.115%
cidity of whey at dipping	.130%	.122%	.131%
cidity of whey at packing	.150%	.148%	.155%
cidity of whey at milling	.58%	.52%	.58%
ime of adding starter	9:45	10:40	11:10
ime of adding rennet			
ime of cutting			
ime steam on	The clock method followed		
ime steam off			
ime dipped			
ime milled			
ime salted			
ime hooped			
ime dressed			
emperature of starter	69°F	69°F	69°F
emperature of setting	86°F	86°F	86°F
emperature of cooking	102°F	102°F	102°F
emperature of hooping	90°F	90°F	90°F
H at cutting	6.10	6.15	6.05
H at dipping	6.00	6.10	6.00
H at milling	5.25	5.32	5.20
H one week old			
ype of cheese made		Cheddar	
ield per cwt. of milk			
ield per pound of fat			
ercent moisture			
ercent fat			
core of cheese			

BIBLIOGRAPHY

(1) Thenard, F., 1819 Traite' de Chimie. France.

(2) Jablin, L., and Gonnet. 1901 Ann. Chim. Anal. Appl. 6:129. Chem. Zentr., 1173.

(3) Chick, H. 1901 Zentr. Bakt. Parasitenk. 11:7, 705.

(4) Risam, A. 1902 Zentr. Bakt. Parasitenk. 11, 8, 739, 769. Chem. Zentr. I:894.

(5) Gordon, L., 1905 Zent. Bakt. Parasitenk. 11, 15. 716 (1904) Chem. Zentr., (1905) 1, 551.

(6) Bonjean, B., 1910 Ann. Falsifications. 2, 411 (1909) Chem. Zentr. (1910) I:1280.

(7) Budde, C., 1903 A new method of sterilizing milk. Nord. Mejeritidning. 18:6566.

(8) Bohme, A., Much, H., and Romer. C. H., 1906 Deut. med. Wocholer, 32:1729-1733.

(9) American public health Assn. Standard methods for the examination of dairy products. 1939 Copyright 133365. Library of Congress.

(10) Matheson, K. T., Bajer, A. J., and McDonald, H. W., 1927 The use of various forms of oxygen in the treatment of abnormal germentation in Swiss cheese. Jour. of Dairy Sci. 10:53,32.

(11) Curran, R. H., Evans, R. F., and Leviton, A., September 1940. The sporicidal action of hydrogen peroxide. Jour. of Bact. 40:423-34.

(12) Krukovsky, V., and Guthrie, F. S., May 1946 Vitamin C, H_2O_2, Copper and the tallowy flavor in milk. Jour. of Dairy Sci. 29:293-76

(13) Steinman, H. G., and Lawson, C. R., 1942 On the mechanism of ascorbic acid oxidase reaction. Jour. Ann. Chem. Soc. Jour. 64:1212-1219.

(14) Payne, J. H., and Foster, L., October 1945 The action of H_2O_2 on carbohydrates. Ann. Chem. Soc. Jour.

(15) Hawk, P. B., Oser, B. L., and Summerson, W. H., 1947 Practical physiological chemistry. 12th edition. Philadelphia.

(16) Wilson, H., 1943 Making American cheddar cheese of uniformly good quality. Circ. B.O.I.M. 947. Bureau of Dairy Industry. Agr. Research Adm., U. S. Dept. of Agr. November 1943. Nat. Butter and Cheese Jour. 34, No. 1 12-15. 1943.

(17) Wilster, G. H., 1937 Determination of fat, moisture and salt in hard cheese. Jour. of Dairy Sci., 20 (1) 27.

(18) _____Manual of instructions for operation of the Brabender moisture tester. Brabender Corporation, Rochelle Park, New Jersey.

(19) Hastings, E. G., and McCoy. 1932 Jour. Bact. 23:45

(20) Gunning, C., and Arnold. 1914 Jour. of Ind. and Eng. Chem. Vol. 6, pp 131.

(21) Porter, J. R., 1946. Bacterial chemistry and physiology. New York. John Wiley and Sons, Inc.

(22) Associates of Rogers, L. Fundamentals of Dairy Sci. Second edition. Reinhold Publishing Corporation.